Chapter 13

1. $\frac{\text{Rate}_{\text{nitrogen}}}{\text{Rate}_{\text{neon}}} = \sqrt{\frac{20.2\ \cancel{\text{g/mol}}}{28.0\ \cancel{\text{g/mol}}}} = \sqrt{0.721} = 0.849$

2. $\frac{\text{Rate}_{\text{carbon monoxide}}}{\text{Rate}_{\text{carbon dioxide}}} = \sqrt{\frac{44.0\ \cancel{\text{g/mol}}}{28.0\ \cancel{\text{g/mol}}}}$

$= \sqrt{1.57}$

$= 1.25$

3. Rearrange Graham's law to solve for Rate_A.

$\text{Rate}_A = \text{Rate}_B \times \sqrt{\frac{\text{molar mass}_B}{\text{molar mass}_A}}$

$\text{Rate}_B = 3.6$ mol/min

$\frac{\text{molar mass}_B}{\text{molar mass}_A} = 0.5$

$\text{Rate}_A = 3.6 \text{ mol/min} \times \sqrt{0.5}$

$= 3.6 \text{ mol/min} \times 0.71$

$= 2.5$ mol/min

4. $P_{\text{hydrogen}} = P_{\text{total}} - P_{\text{helium}}$

$= 600 \text{ mm Hg} - 439 \text{ mm Hg}$

$= 161$ mm Hg

5. $P_{\text{total}} = 5.00 \text{ kPa} + 4.56 \text{ kPa} + 3.02 \text{ kPa} + 1.20 \text{ kPa}$

$= 13.78$ kPa

6. $P_{\text{carbon dioxide}} = 30.4 \text{ kPa} - (16.5 \text{ kPa} + 3.7 \text{ kPa})$

$= 30.4 \text{ kPa} - 20.2 \text{ kPa} = 10.2$ kPa

Chapter 14

1. $V_2 = \frac{V_1P_1}{P_2} = \frac{(300.0 \text{ mL})(99.0\cancel{\text{kPa}})}{188\ \cancel{\text{kPa}}} = 158$ mL

2. $P_2 = \frac{V_1P_1}{V_2} = \frac{(1.00\ \cancel{\text{L}})(0.988 \text{ atm})}{2.00\ \cancel{\text{L}}} = 0.494$ atm

3. $V_2 = \frac{V_1P_1}{P_2} = \frac{(145.7 \text{ mL})(1.08\ \cancel{\text{atm}})}{1.43\ \cancel{\text{atm}}}$

$= 1.10 \times 10^2$ mL

4. $P_2 = \frac{V_1P_1}{V_2} = \frac{(4.00\ \cancel{\text{L}})(0.980 \text{ atm})}{0.0500\ \cancel{\text{L}}} = 78.4$ atm

5. $29.2\ \cancel{\text{kPa}} \times \frac{1 \text{ atm}}{101.3\ \cancel{\text{kPa}}} = 0.288$ atm

$V_2 = \frac{V_1P_1}{P_2} = \frac{(0.220 \text{ L})(0.860\ \cancel{\text{atm}})}{0.288\ \cancel{\text{atm}}} = 0.657$ L

6. $T_1 = 89°\text{C} + 273 = 362$ K

$T_2 = \frac{T_1V_2}{V_1} = \frac{(362 \text{ K})(1.12\ \cancel{\text{L}})}{0.67\ \cancel{\text{L}}} = 605$ K

$605 - 273 = 330°\text{C}$

7. $T_1 = 80.0°\text{C} + 273 = 353$ K

$T_2 = 30.0°\text{C} + 273 = 303$ K

$V_2 = \frac{V_1T_2}{T_1} = \frac{(3.00 \text{ L})(303\ \cancel{\text{K}})}{353\ \cancel{\text{K}}} = 2.58$ L

8. $T_1 = 25°\text{C} + 273 = 298$ K

$T_2 = 0.00°\text{C} + 273 = 273$ K

$V_2 = \frac{V_1T_2}{T_1} = \frac{(0.620 \text{ L})(273\ \cancel{\text{K}})}{298\ \cancel{\text{K}}} = 0.57$ L

9. $T_1 = 30.0°\text{C} + 273 = 303$ K

$T_2 = \frac{T_1P_2}{P_1} = \frac{(303 \text{ K})(201\ \cancel{\text{kPa}})}{125\ \cancel{\text{kPa}}} = 487$ K

$487 \text{ K} - 273 = 214°\text{C}$

10. $T_1 = 25.0°\text{C} + 273 = 298$ K

$T_2 = 37.0°\text{C} + 273 = 310$ K

$P_2 = \frac{P_1T_2}{T_1} = \frac{(1.88 \text{ atm})(310\ \cancel{\text{K}})}{298\ \cancel{\text{K}}} = 1.96$ atm

11. $T_2 = 36.5°\text{C} + 273 = 309.5$ K

$T_1 = \frac{T_2P_1}{P_2} = \frac{(309.5 \text{ K})(1.12\ \cancel{\text{atm}})}{2.56\ \cancel{\text{atm}}} = 135$ K

$135 \text{ K} - 273 = -138°\text{C}$

12. $T_1 = 0.00°\text{C} + 273 = 273$ K

$T_2 = \frac{T_1P_2}{P_1} = \frac{(273 \text{ K})(28.4\ \cancel{\text{kPa}})}{30.7\ \cancel{\text{kPa}}} = 252.5$ K

$252.5 \text{ K} - 273 = -20.5°\text{C} = -21°\text{C}$

The temperature must be lowered by 21°C.

13. $T_1 = 22.0°\text{C} + 273 = 295$ K

$T_2 = 44.6°\text{C} + 273 = 318$ K

$P_2 = \frac{P_1T_2}{P_1} = \frac{(660 \text{ torr})(318\ \cancel{\text{K}})}{295\ \cancel{\text{K}}} = 711$ torr

$711 \text{ torr} - 660 \text{ torr} = 51$ torr more

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$T_2 = 0.00°\text{C} + 273 = 273\ \text{K}$

$V_2 = \frac{V_1T_2}{T_1} = \frac{(0.620\ \text{L})(273\ \cancel{\text{K}})}{298\ \cancel{\text{K}}} = 0.57\ \text{L}$

9. $T_1 = 30.0°\text{C} + 273 = 303\ \text{K}$

$T_2 = \frac{T_1P_2}{P_1} = \frac{(303\ \text{K})(201\ \cancel{\text{kPa}})}{125\ \cancel{\text{kPa}}} = 487\ \text{K}$

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$T_2 = 37.0°\text{C} + 273 = 310\ \text{K}$

$P_2 = \frac{P_1T_2}{T_1} = \frac{(1.88\ \text{atm})(310\ \cancel{\text{K}})}{298\ \cancel{\text{K}}} = 1.96\ \text{atm}$

11. $T_2 = 36.5°\text{C} + 273 = 309.5\ \text{K}$

$T_1 = \frac{T_2P_1}{P_2} = \frac{(309.5\ \text{K})(1.12\ \cancel{\text{atm}})}{2.56\ \cancel{\text{atm}}} = 135\ \text{K}$

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12. $T_1 = 0.00°\text{C} + 273 = 273\ \text{K}$

$T_2 = \frac{T_1P_2}{P_1} = \frac{(273\ \text{K})(28.4\ \cancel{\text{kPa}})}{30.7\ \cancel{\text{kPa}}} = 252.5\ \text{K}$

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The temperature must be lowered by 21°C.

13. $T_1 = 22.0°\text{C} + 273 = 295\ \text{K}$

$T_2 = 44.6°\text{C} + 273 = 318\ \text{K}$

$P_2 = \frac{P_1T_2}{P_1} = \frac{(660\ \text{torr})(318\ \cancel{\text{K}})}{295\ \cancel{\text{K}}} = 711\ \text{torr}$

$711\ \text{torr} - 660\ \text{torr} = 51\ \text{torr more}$

19. $T_1 = 36°C + 273 = 309\ K$

$T_2 = 28°C + 273 = 301\ K$

$$V_2 = \frac{P_1T_2V_1}{P_2T_1} = \frac{(0.998\ \text{atm})(301\ \text{K})(2.1\ \text{L})}{(0.900\ \text{atm})(309\ \text{K})} = 2.3\ \text{L}$$

20. $T_1 = 0.00°C + 273 = 273\ K$

$T_2 = 30.00°C + 273 = 303\ K$

$$P_2 = \frac{V_1T_2P_1}{V_2T_1} = \frac{(30.0\ \text{mL})(303\ \text{K})(1.00\ \text{atm})}{(20.0\ \text{mL})(273\ \text{K})}$$

$= 1.66\ \text{atm}$

21. $T_1 = 22.0°C + 273 = 295\ K$

$T_2 = 100.0°C + 273 = 373\ K$

$$V_1 = \frac{V_2T_1P_2}{T_2P_1} = \frac{(0.224\ \text{mL})(295\ \text{K})(1.23\ \text{atm})}{(373\ \text{K})(1.02\ \text{atm})}$$

$= 0.214\ \text{mL}$

22. $T_1 = 5.0°C + 273 = 278\ K$

$T_2 = 2.09°C + 273 = 275\ K$

$$V_2 = \frac{P_1T_2V_1}{P_2T_1} = \frac{(1.30\ \text{atm})(275\ \text{K})(46.0\ \text{mL})}{(1.52\ \text{atm})(278\ \text{K})}$$

$= 39\ \text{mL}$

23. $$P_1 = \frac{V_2T_1P_2}{V_1T_2} = \frac{(0.644\ \text{L})(298\ \text{K})(32.6\ \text{kPa})}{(0.766\ \text{L})(303\ \text{K})} =$$

$= 27.0\ \text{kPa}$

24. $$2.4\ \text{mol} \times \frac{22.4\ \text{L}}{\text{mol}} = 54\ \text{L}$$

25. $$0.0459\ \text{mol} \times \frac{22.4\ \text{L}}{\text{mol}} = 1.03\ \text{L}$$

26. $$1.02\ \text{mol} \times \frac{22.4\ \text{L}}{\text{mol}} = 22.8\ \text{L}$$

27. $$2.00\ \text{L} \times \frac{1\ \text{mol}}{22.4\ \text{L}} = 0.0893\ \text{mol}$$

28. Set up problem as a ratio.

$$\frac{?\ \text{mol He}}{0.865\ \text{L}} = \frac{0.0226\ \text{mol He}}{0.460\ \text{L}}$$

Solve for mol He.

$$?\ \text{mol He} = \frac{0.0226\ \text{mol He}}{0.460\ \text{L}} \times 0.865\ \text{L}$$

$= 0.0425\ \text{mol He}$

29. $$1.0\ \text{L} \times \frac{1\ \text{mol}}{22.4\ \text{L}} = 0.045\ \text{mol}$$

$$0.045\ \text{mol} \times \frac{44.0\ \text{g}}{\text{mol}} = 2.0\ \text{g}$$

30. $$0.00922\ \text{g} \times \frac{1\ \text{mol}}{2.016\ \text{g}} = 0.00457\ \text{mol}$$

$$0.00457\ \text{mol} \times \frac{22.4\ \text{L}}{\text{mol}} = 0.102\ \text{L or } 102\ \text{mL}$$

31. $$0.416\ \text{g} \times \frac{1\ \text{mol}}{83.8\ \text{g}} = 0.00496\ \text{mol}$$

$$0.00496\ \text{mol} \times \frac{22.4\ \text{L}}{\text{mol}} = 0.111\ \text{L}$$

32. $0.860\ \text{g} - 0.205\ \text{g} = 0.655\ \text{g He remaining}$

Set up problem as a ratio.

$$\frac{V}{0.655\ \text{g}} = \frac{19.2\ \text{L}}{0.860\ \text{g}}$$

Solve for V.

$$V = \frac{(19.2\ \text{L})(0.655\ \text{g})}{0.860\ \text{g}} = 14.6\ \text{L}$$

33. $$4.5\ \text{kg} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol}}{28.0\ \text{g}} \times \frac{22.4\ \text{L}}{1\ \text{mol}} = 3.6 \times 10^3\ \text{L}$$

41. $$n = \frac{PV}{RT} = \frac{(3.81\ \text{atm})(0.44\ \text{L})}{\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(298\ \text{K})}$$

$= 6.9 \times 10^{-3}\ \text{mol}$

42. $$143\ \text{kPa} \times \frac{1.00\ \text{atm}}{101.3\ \text{kPa}} = 1.41\ \text{atm}$$

$$T = \frac{PV}{nR} = \frac{(1.41\ \text{atm})(1.00\ \text{L})}{(2.49\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)} = 6.90\ \text{K}$$

$6.90\ \text{K} - 273 = -266°C$

43. $$V = \frac{nRT}{P} = \frac{(0.323\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(265\ \text{K})}{0.900\ \text{atm}}$$

$= 7.81\ \text{L}$

44. $T = 20.0°C + 273 = 293\ K$

$$P = \frac{nRT}{V} = \frac{(0.108\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(293\ \text{K})}{0.505\ \text{L}}$$

$= 5.14\ \text{atm}$

45. $$T = \frac{PV}{nR} = \frac{(0.988\ \text{atm})(1.20\ \text{L})}{(0.0470\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)} = 307\ \text{K}$$

46. $$117\ \text{kPa} \times \frac{1.00\ \text{atm}}{101.3\ \text{kPa}} = 1.15\ \text{atm}$$

$T = 35.1°C + 273 = 308\ K$

$$m = \frac{PMV}{RT} = \frac{(1.15\ \text{atm})(70.0\ \text{g/mol})(2.00\ \text{L})}{\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(308\ \text{K})}$$

$= 6.39\ \text{g}$

47. $T = 22.0°C + 273 = 295\ K$

$$m = \frac{MPV}{RT} = \frac{(28.0\ \text{g/mol})(1.00\ \text{atm})(0.600\ \text{L})}{\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(295\ \text{K})}$$

$= 0.694\ \text{g}$

48. $D = \frac{PM}{RT} = \frac{(1.00\ \text{atm})(44.0\ \text{g/mol})}{\left(0.0821\frac{\text{L·atm}}{\text{mol·K}}\right)(273\ \text{K})} = 1.96\ \text{g/L}$

49. $T = 25.0°\text{C} + 273 = 298\ \text{K}$

$$M = \frac{DRT}{P} = \frac{(1.09\ \text{g/L})\left(0.0821\frac{\text{L·atm}}{\text{mol·K}}\right)(298\ \text{K})}{1.02\ \text{atm}}$$

$= 26.1\ \text{g/mol}$

50. $D = \frac{MP}{RT} = \frac{(39.9\ \text{g/mol})(1.00\ \text{atm})}{\left(0.0821\frac{\text{L·atm}}{\text{mol·K}}\right)(273\ \text{K})} = 1.78\ \text{g/L}$

56. $S(s) + O_2(g) \rightarrow SO_2(g)$

$$3.5\ \text{L}\ SO_2 \times + \frac{1\ \text{volume}\ O_2}{1\ \text{volume}\ SO_2} = 3.5\ \text{L}\ O_2$$

57. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

$$5.00\ \text{L}\ O_2 \times \frac{2\ \text{volumes}\ H_2}{1\ \text{volume}\ O_2} = 10.0\ \text{L}\ H_2$$

58. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

$$34.0\ \text{L}\ O_2 \times \frac{1\ \text{volume}\ C_3H_8}{5\ \text{volumes}\ O_2} = 6.80\ \text{L}\ C_3H_8$$

59. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

$$2.36\ \text{L}\ CH_4 \times \frac{2\ \text{volumes}\ O_2}{1\ \text{volume}\ CH_4} = 4.72\ \text{L}\ O_2$$

60. $0.100\ \text{L}\ N_2O \times \frac{1\ \text{mol}}{22.4\ \text{L}} = 0.00446\ \text{mol}\ N_2O$

$$0.00446\ \text{mol}\ N_2O \times \frac{1\ \text{mol}\ NH_4NO_3}{1\ \text{mol}\ N_2O}$$

$= 0.00446\ \text{mol}\ NH_4NO_3$

$0.00446\ \text{mol}\ NH_4NO_3 \times 80.0\ \text{g/mol}$

$= 0.357\ \text{g}\ NH_4NO_3$

61. $2.38\ \text{kg} \times \frac{1000\ \text{g}}{\text{kg}} \times \frac{1\ \text{mol}\ CaCO_3}{100.0\ \text{g}} \times$

$$\frac{1\ \text{mol}\ CO_2}{1\ \text{mol}\ CaCO_3} \times \frac{22.4\ \text{L}}{1\ \text{mol}} = 533\ \text{L}\ CO_2$$

62. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

$$n = \frac{PV}{RT} = \frac{(1.00\ \text{atm})(10.5\ \text{L})}{\left(0.0821\frac{\text{L·atm}}{\text{mol·K}}\right)(473\ \text{K})}$$

$= 0.271\ \text{mol}\ CH_4$

$$0.271\ \text{mol}\ CH_4 \times \frac{2\ \text{mol}\ H_2O}{1\ \text{mol}\ CH_4} = 0.541\ \text{mol}\ H_2O$$

63. $52.0\ \text{g Fe} \times \frac{1\ \text{mol Fe}}{55.85\ \text{g Fe}} \times \frac{3\ \text{mol}\ O_2}{4\ \text{mol Fe}} \times \frac{22.4\ \text{L}}{1\ \text{mol}}$

$= 15.6\ \text{L}\ O_2$

64. $2K(s) + Cl_2(g) \rightarrow 2KCl(s)$

$$0.204\ \text{g K} \times \frac{1\ \text{mol K}}{39.1\ \text{g K}} \times \frac{1\ \text{mol}\ Cl_2}{2\ \text{mol K}} \times \frac{22.4\ \text{L}}{1\ \text{mol}}$$

$= 0.0584\ \text{L}\ Cl_2$